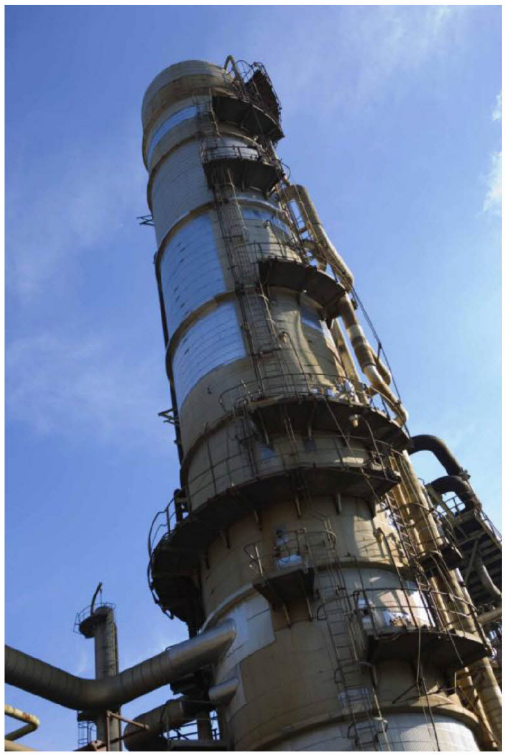
Corrosion by HCl



Senior Analyst and Inspector Training
Crude Units

Corrosion by Hydrochloric Acid (HCl)

Characteristics

- Only occurs where liquid water is present
- Is very aggressive below pH 4-5 (be careful, depending on neutralizer used, the first or last drops of condensate can have much lower pH than bulk water in the reflux drum)
- Can cause both pitting and general thinning
- Corrosion is very velocity sensitive

Corrosion by Hydrochloric Acid (HCl) (Cont'd)

Prevention

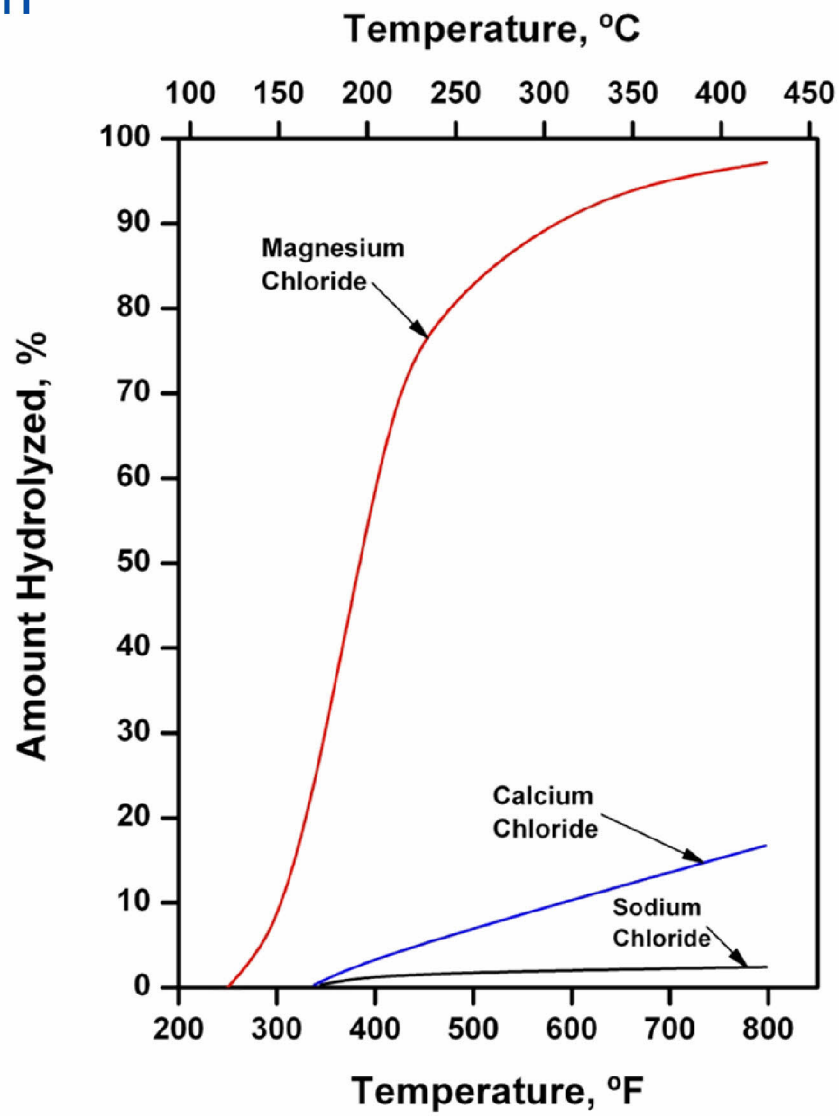
- Water injection, at least 30% unvaporized, to reduce chloride concentrations and minimize pH variations
- Neutralization (ammonia preferred, neutralizing amines if effective water injection is not available)
- Maintain overhead water pH at 7.0-7.5
- Good desalting - 0.5 lb salt per thousand barrels oil max. (1.4 kg/1000 m^3)
- Caustic injection for further salt removal
- Use alloys such as Monel, titanium, C-276
  - Avoid 300 Series SS
  - Copper alloys are better than steel but not as good as Monel or titanium
- Filming amines can cause fouling and shouldn't be necessary in a well designed corrosion control program

Corrosion by Hydrochloric Acid (HCl) (Cont'd)

Inspection

- See Inspection Strategy IS-6 (API 571 #9)
  - UT/RT at elbows, reducers, and other turbulent locations
  - UT/RT at stagnant and low flow areas, such as dead legs
  - Eddy current, IRIS, and/or laser optics for exchanger tubes — visual inspection at tube inlets
  - Visual inspection at top of column

Hydrolysis of Chlorides in Crude Oil as a Function of Temperature



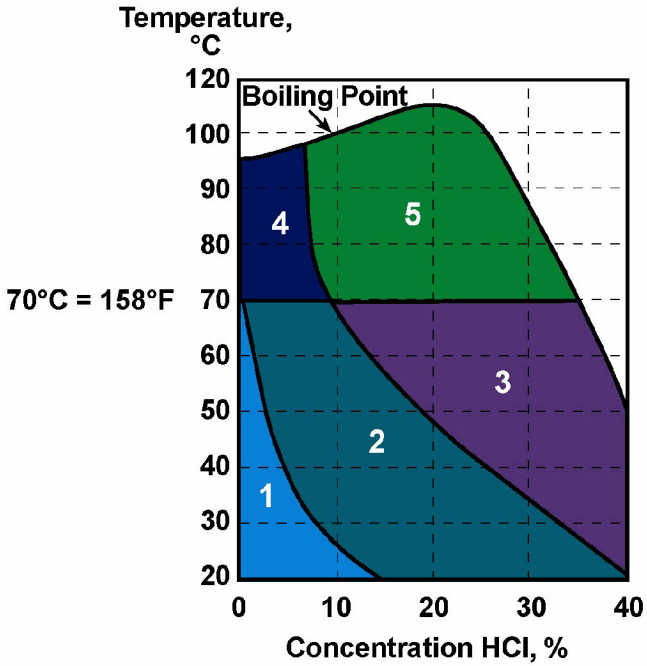
Resistance to Chloride Pitting

	Pitting Index (% Cr + 3.3 x % Mo + 16 x % N
(Hastelloy C-276), (Inconel 625), (Hastelloy C-22)	50-70
Hastelloy G, AL6XN, Carpenter 20 Mo-6, Duplex 2507	40-43
904L, Duplex 2205	34-35
Incoloy 825, Alloy 20 Cb-3	28-31
Incoloy 800, (Inconel 600), 316L SS	16-25
304L SS, 321 SS	17-18
410 SS, 430 SS	12-17
Carbon Steel and Cr-Mo Steels	0-5

Increasing Resistance ↑

Note: Pitting Index Not Valid for Alloys in Parentheses

Alloys for Hydrochloric Acid Service



Materials in Numbered Zones Have Reported Corrosion Rates of <20 mpy

ZONE 1			
CN-7M	(1)	(3)	(6)
400 Alloy	(2)	(3)	(6)
Copper	(2)	(3)	(6)
Nickel 200	(2)	(3)	(6)
Silicon Bronze	(2)	(3)	(6)
Silicon Cast Iron	(7)		
Tungsten			
Titanium (Gr. 7)			
Titanium (Gr. 2)	(4)		

ZONE 2		
Silicon Bronze	(2)	(6)
Silicon Cast Iron	(7)	

ZONE 3	
Silicon Cast Iron	(7)

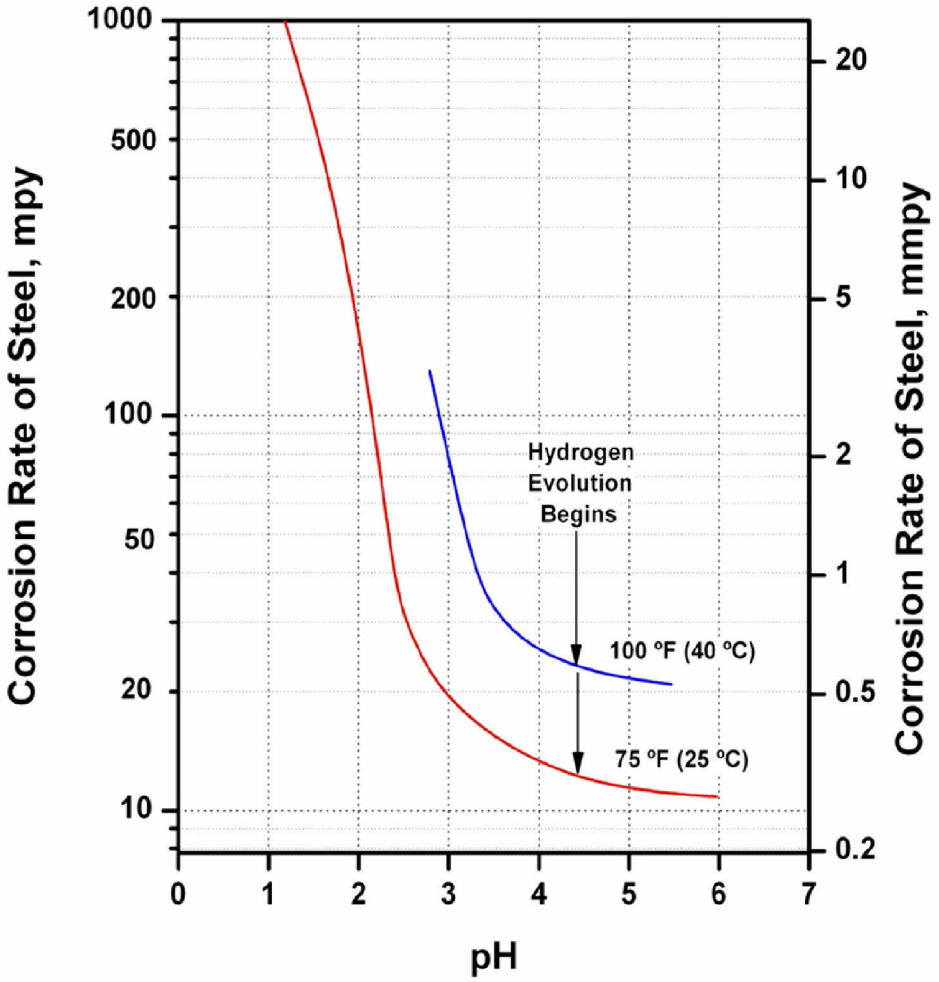
ZONE 4			
400 Alloy	(2)	(3)	(8)
Tungsten			
Titanium (Gr. 7)	(5)		

ALL ZONES (Including 5)		
Platinum		
Tantalum		
Silver	(3)	(6)
Zirconium	(3)	(6)
B-2 Alloy	(3)	(6)
Molybdenum	(3)	(6)

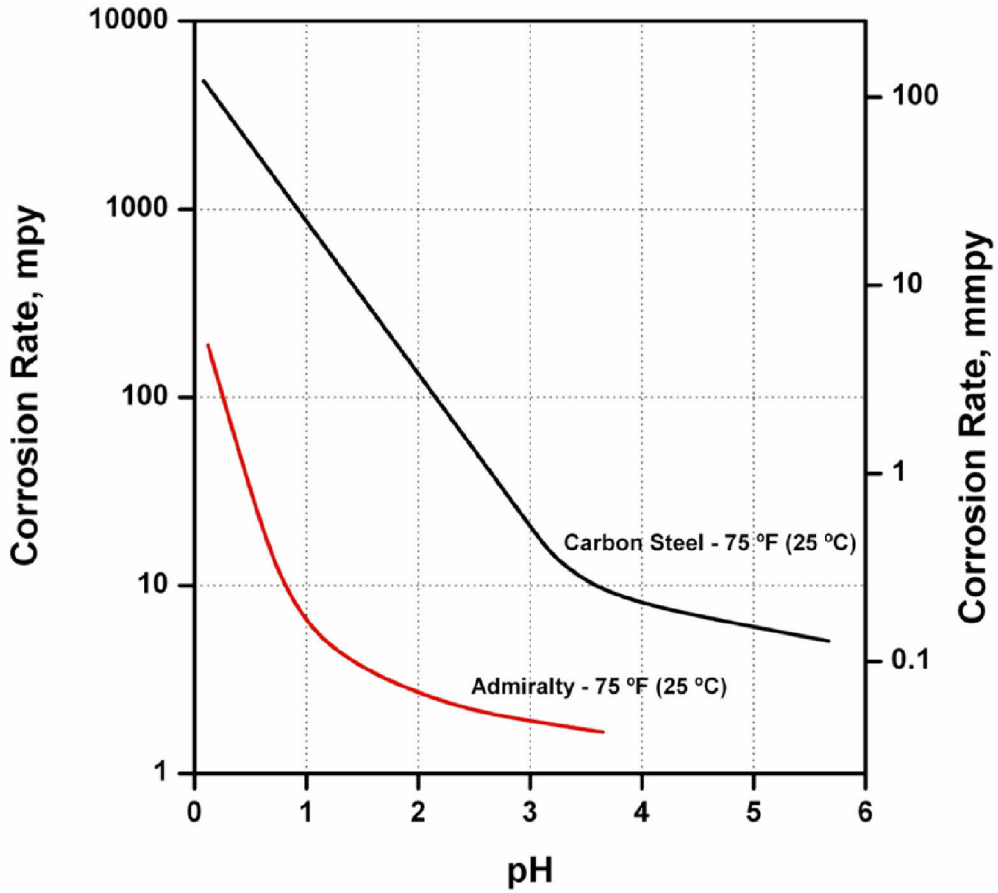
NOTES:

1. <2% at 25°C
2. No Air
3. No $FeCl_3$ or $CuCl_2$
4. <10% at 25°C
5. <5% at B.P.
6. No Chorine
7. Cr-Mo Alloy
8. <0.05% Concentration

Carbon Steel in Unagitated Hydrochloric Acid

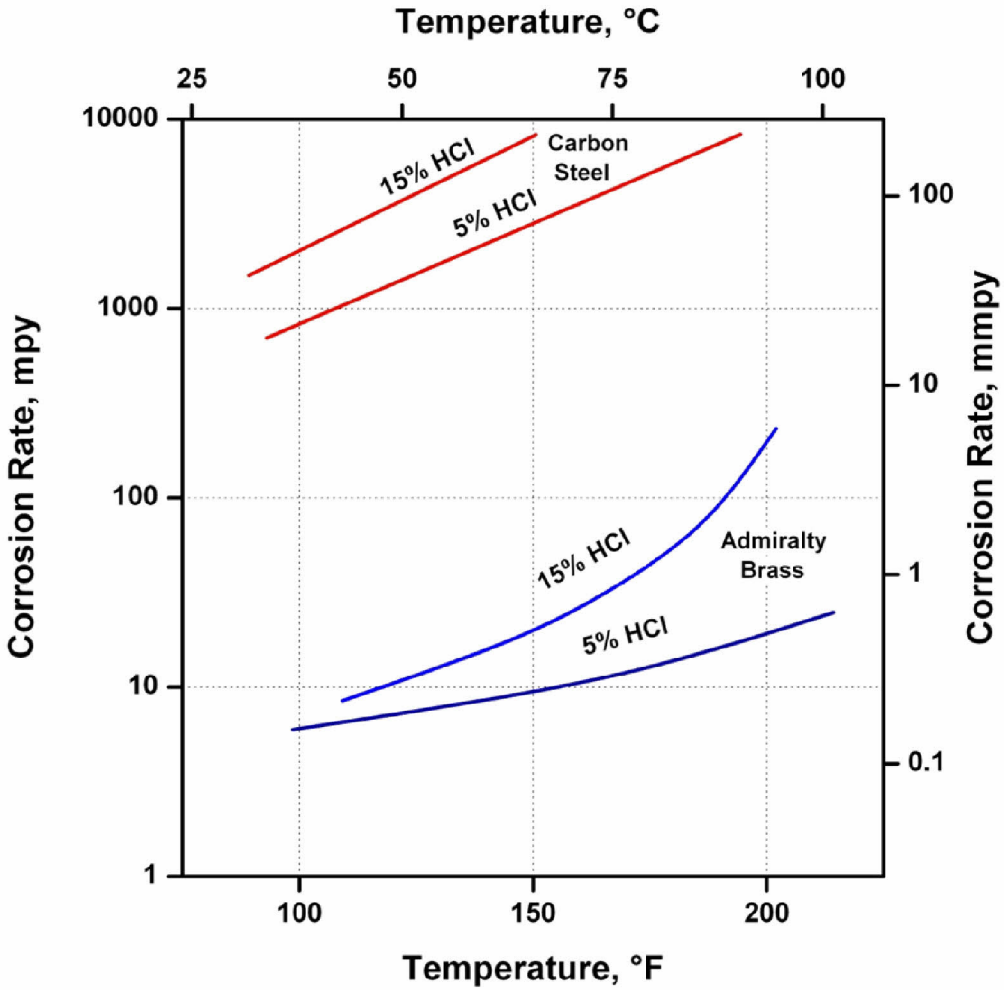


Effect of HCl Concentration (pH) on Corrosion of Carbon Steel and Admiralty Brass in Unagitated Solutions



pH Versus Acid Conc.	
pH	HCl Conc.
0	3.5%
1	0.35%
2	0.065%
3	35 ppm
4	3.5 ppm
5	0.35 ppm

Corrosion Rate of Carbon Steel and Admiralty Brass in Unagitated HCl at Various Temperatures



pH Versus Acid Conc.	
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0	3.5%
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5	0.35 ppm

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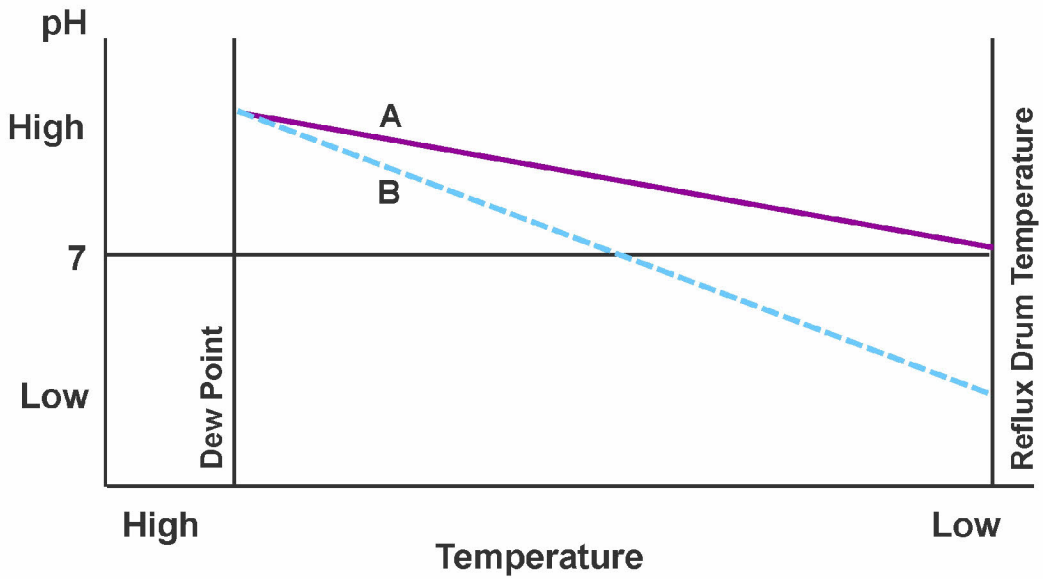
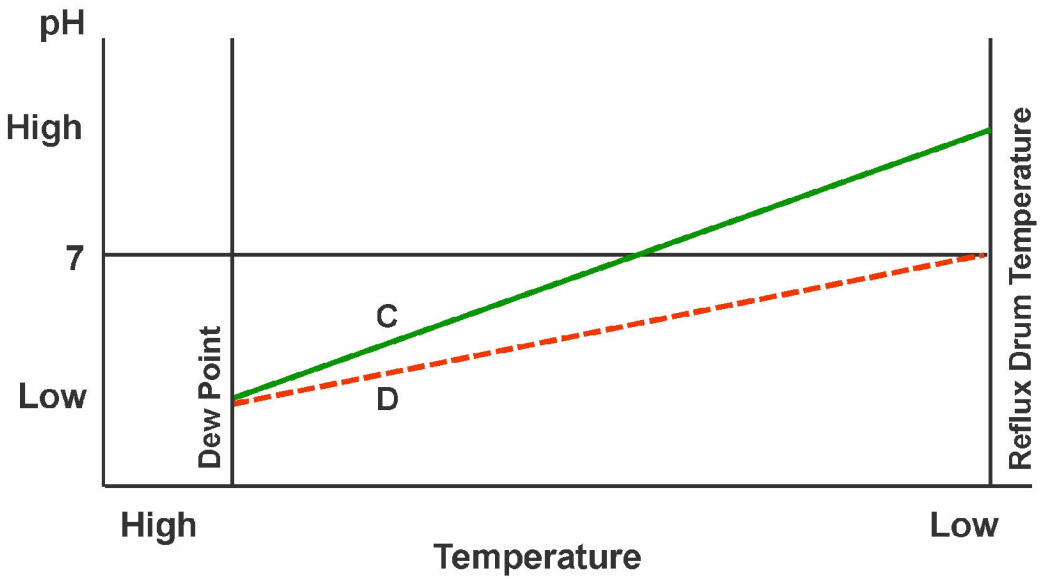
Neutralizer Characteristics – Amine



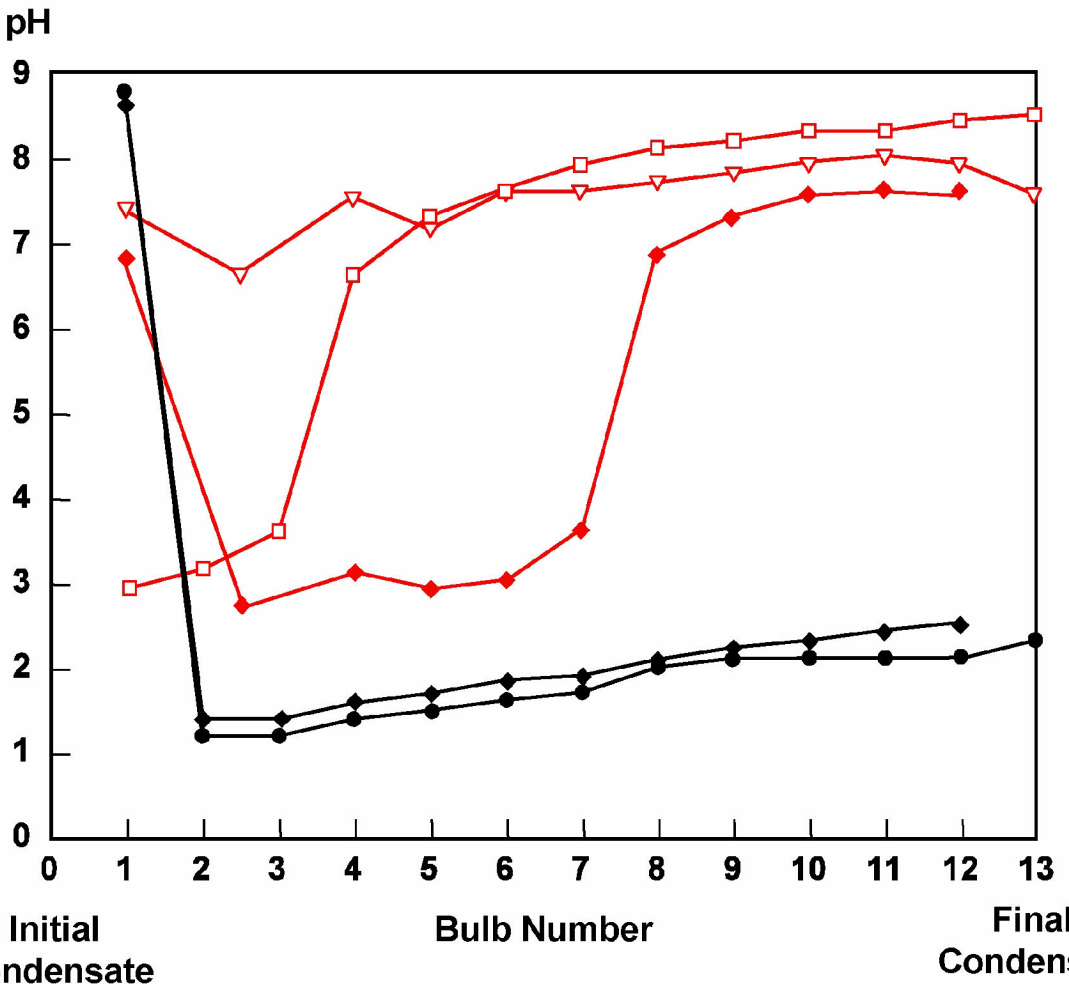
	Neutralizing Amine
pH of individual water droplets that are condensing at the indicated temp.	Curve "B"
pH of total water that has condensed at any given temp.	Curve "A"

Neutralizer Characteristics – Ammonia



	Ammonia
pH of individual water droplets that are condensing at the indicated temp.	Curve "C"
pH of total water that has condensed at any given temp.	Curve "D"

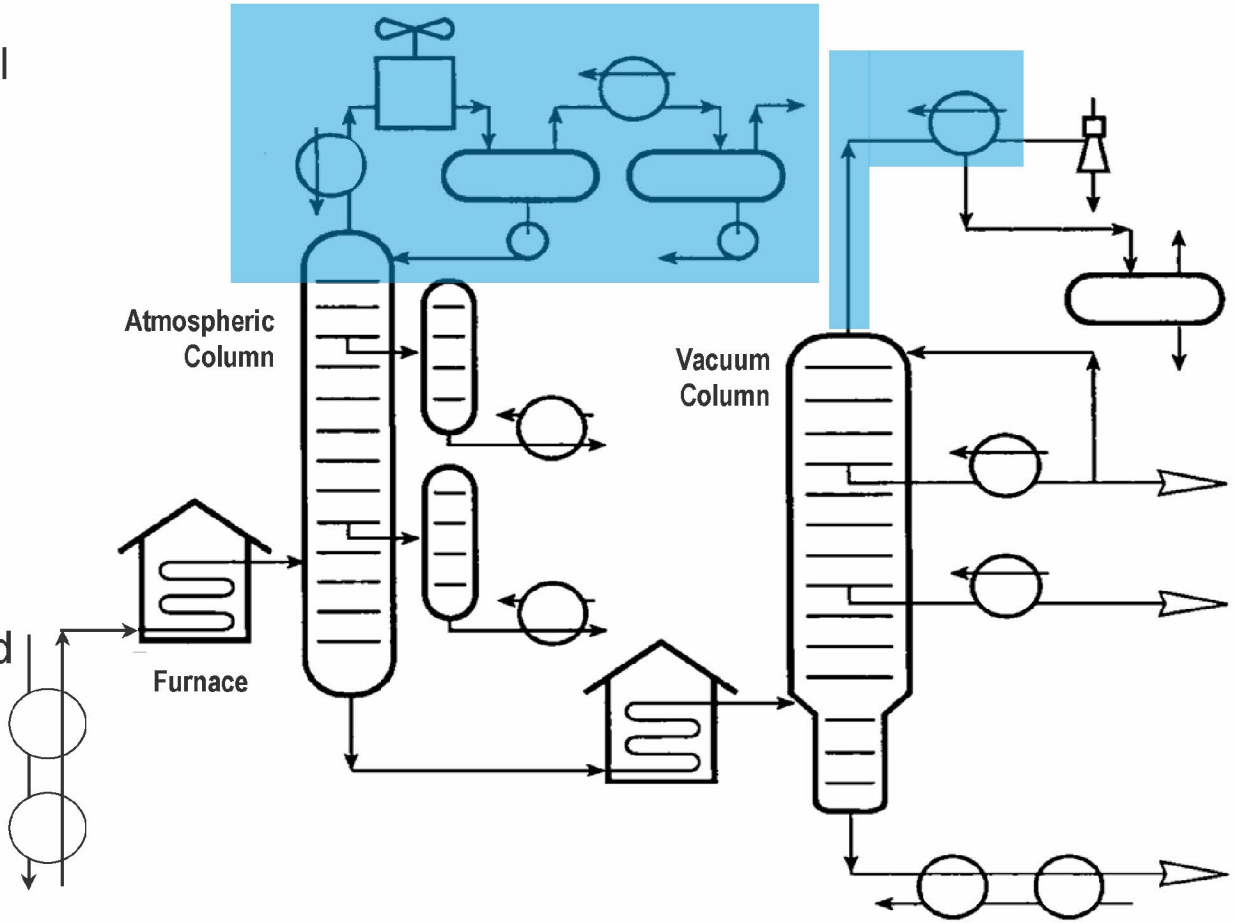
Summary of Simulation Tests for Various Overhead System Neutralizing Schemes (Nalco Data)



- EDA, Sour, 221°F (105°C)
- EDA, Sour, 220°F (104.4°C), 20% WW
- NH_3, Sour, 330°F (165.6°C)
- NH_3, Sour, 223°F (106.1°C), 20% WW
- NH_3, Sour, 220°F (104.4°C), 33% WW

Typical Areas in Crude Units Susceptible to HCl Corrosion

- Occurs where HCl and liquid water present
- Aggressive below pH 4-5
- Both pitting and general thinning
- Velocity-sensitive
- To prevent, maintain overhead pH at 7.0-7.5



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